

is lower than that of Cu. Therefore, for the high-conductivity layer to be adjacent to CoFe, Cu is preferred to Ru. Too thick Ru is unfavorable, as not satisfying narrow gaps. For these reasons, therefore, it is desirable that Cu is positioned adjacent to CoFe, while having a thickness of from 0.5 to 1 nanometer or so, and the other additional metal layer is positioned over the Cu layer to give the laminated film for the high-conductivity layer.

Second to Sixth Embodiments: improvement in high-temperature stability and reproduction output power

The second to sixth embodiments of the invention are mentioned below, which are directed to the improvement in the high-temperature stability and the reproduction output power.

First mentioned is the outline of the technical idea common to the second to sixth embodiments.

Fig. 17 shows one example of the second to sixth embodiments of the invention. In Fig. 17, a lower shield 11 and a lower gap film 12 are provided on a substrate 10, and a spin valve device 13 is provided thereon. The spin valve device comprises a spin valve film 14 and a pair of longitudinal bias films 15 and a pair of electrodes 16. The spin valve film 14 comprises nonmagnetic underlayers 141, 142, an antiferromagnetic layer 143, a pinned magnetic layer 144, an interlayer 145, a free layer 146 and a protective film 147.

Table 6 shows the material composition of the

antiferromagnetic layer to be coupled with the ferromagnetic layer in SyAF which is the pinned magnetic layer of the invention, the thickness of the antiferromagnetic layer, the magnetic coupling coefficient  $J$  at  $200^{\circ}\text{C}$ , the magnetic coupling bias field  $H_{\text{UA}}^*$  or  $H_{\text{UA}}$  at  $200^{\circ}\text{C}$ , the blocking temperature  $T_b$ , and the resistance change rate  $\Delta R/R$  in the spin valve device. Table 7 shows the same data as in Table 6, but in Table 7, the pinned magnetic layer is a conventional, single-layered, pinned magnetic layer. Table 8 shows the half-value width of the diffraction peak from the close-packed plane of the antiferromagnetic layer as coupled to SyAF in its rocking curve,  $\Delta\theta$ ; the magnetic coupling coefficient  $J$  at  $200^{\circ}\text{C}$  to the ferromagnetic layer adjacent to the antiferromagnetic layer in SyAF; and the blocking temperature  $T_b$ .

Table 6

Spin Valve Film Constitution:

Substrate/5 nanometer Ta/NiFe/CoFe/3 nm Cu/2.5 nm CoFe/0.9 nm Ru/2.5 nm CoFe/antiferromagnetic layer/5 nanometer Ta

Antiferromagnetic Layer		J (erg/cm <sup>2</sup> ) at 200°C	H <sub>UA</sub> * (Oe) at 200°C	Blocking Temperature T <sub>b</sub> (°C)	Resistance Change Rate ΔR/R (%)
Material	Thickness (nm)				
Ir22Mn78 (comp. case)	5	0.04	400	250	7.3
	7	0.045	450	270	7.3
	1	0.045	450	290	7
	20	0.04	400	300	6.5
	30	0.035	350	300	5.5
Rh20Mn80	7	0.025	250	235	7.1
	10	0.035	350	260	6.8
Rh14Ru7Mn79	7	0.02	200	225	7.2
	10	0.03	300	245	6.8
Pt53Mn47 (comp. case)	10	0.02	250	290	7.9
	15	0.025	400	320	7.4
	20	0.1	>600	350	7
	30	0.12	>600	370	6.2
Ni50Mn30	15	0.02	250	300	6.8
CrMnPt	15	0.02	200	240	6.9

Spin valve films with IrMn, RhMn, RhRuMn or CrMnPt: heat-treated at 270°C for 1 hour.

Spin valve films with PtMn or NiMn: heat-treated at 270°C for 10 hours.